



Foss Barrier, York

York Public Exhibition

Hotel 53, Piccadilly

Friday 20th May and Saturday 21st May

How it works: Foss Barrier, York

The Foss Barrier prevents flood water from the River Ouse from flowing back up the River Foss.

When the gate is closed the water in the Foss then needs to be pumped around the barrier to keep it flowing.

The Barrier works by raising and lowering a barrier gate on steel wire ropes which are wound onto drums at either end of the bridge connecting the two side towers.

A central electric motor (with standby) drives the winding drums.

Barrier gate: When the gate is lowered it seals onto a stainless steel section embedded in the reinforced concrete cill. The horizontal thrust of the water from the River Ouse side (approx 200t) is transmitted into the piled foundations that are piled 10m below the river bed into bedrock.

When it is closed the pumps start automatically; water is pumped from the Foss around the barrier into the Ouse. The level on the Foss is kept at around 7.5m AOD.

When the flood water level on the River Ouse returns to around 7.5m AOD the levels are equal, the flood gate can be raised and the pumps shut down.

When all eight pumps are working in normal conditions the pumps can move 30 cubic meters of water a second, that could completely drain the Foss basin in approximately 30 seconds.

Barrier lift tower:

The barrier is a steel turn-over and lifting gate.

Gate Span: 8.3m

Gate height: 8.25m

Gate weight: 16.5 tonnes

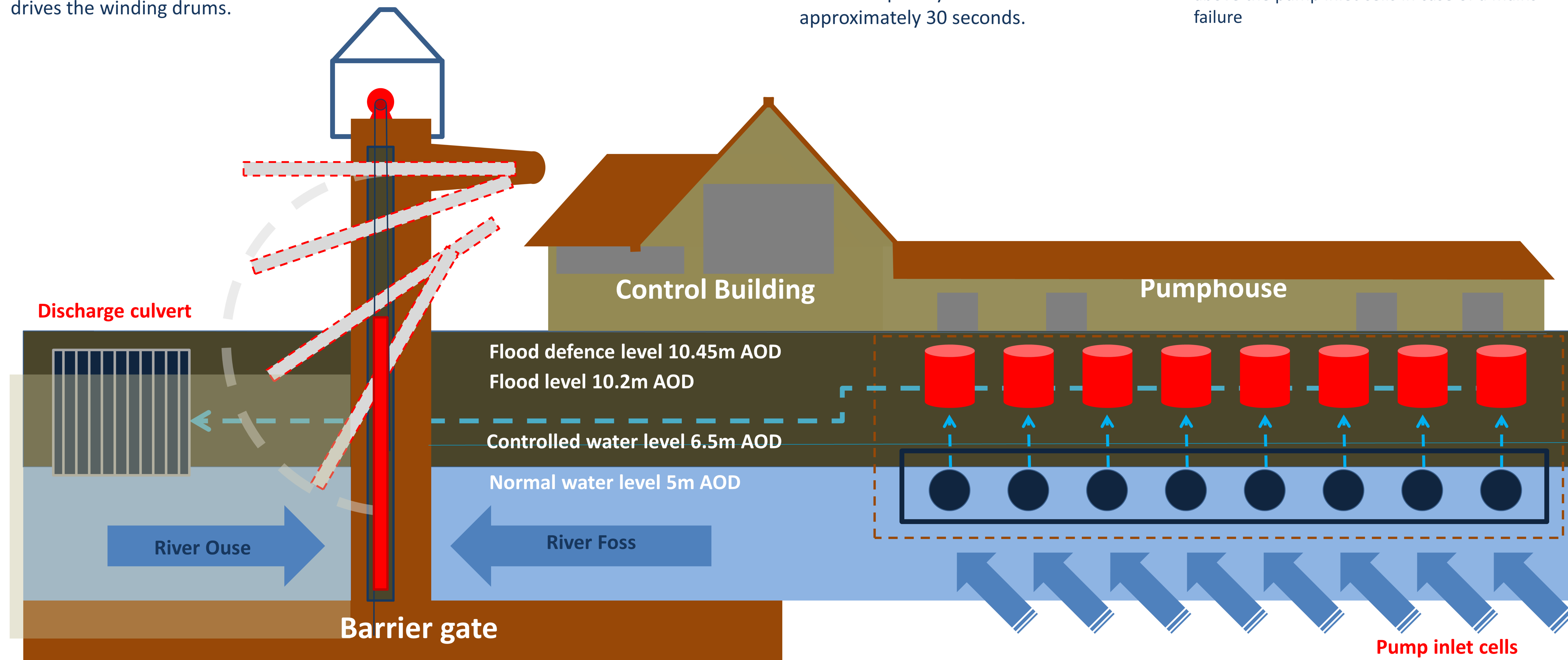
Pumphouse:

Pumps: 8x axial flow propellor electrical pumps

Electric power input: 236kW

maximum capacity 30 cubic meters of water a second (cumecs)

Standby generators are housed in the rooms above the pump inlet cells in case of a mains failure



How it works: Foss Barrier, York

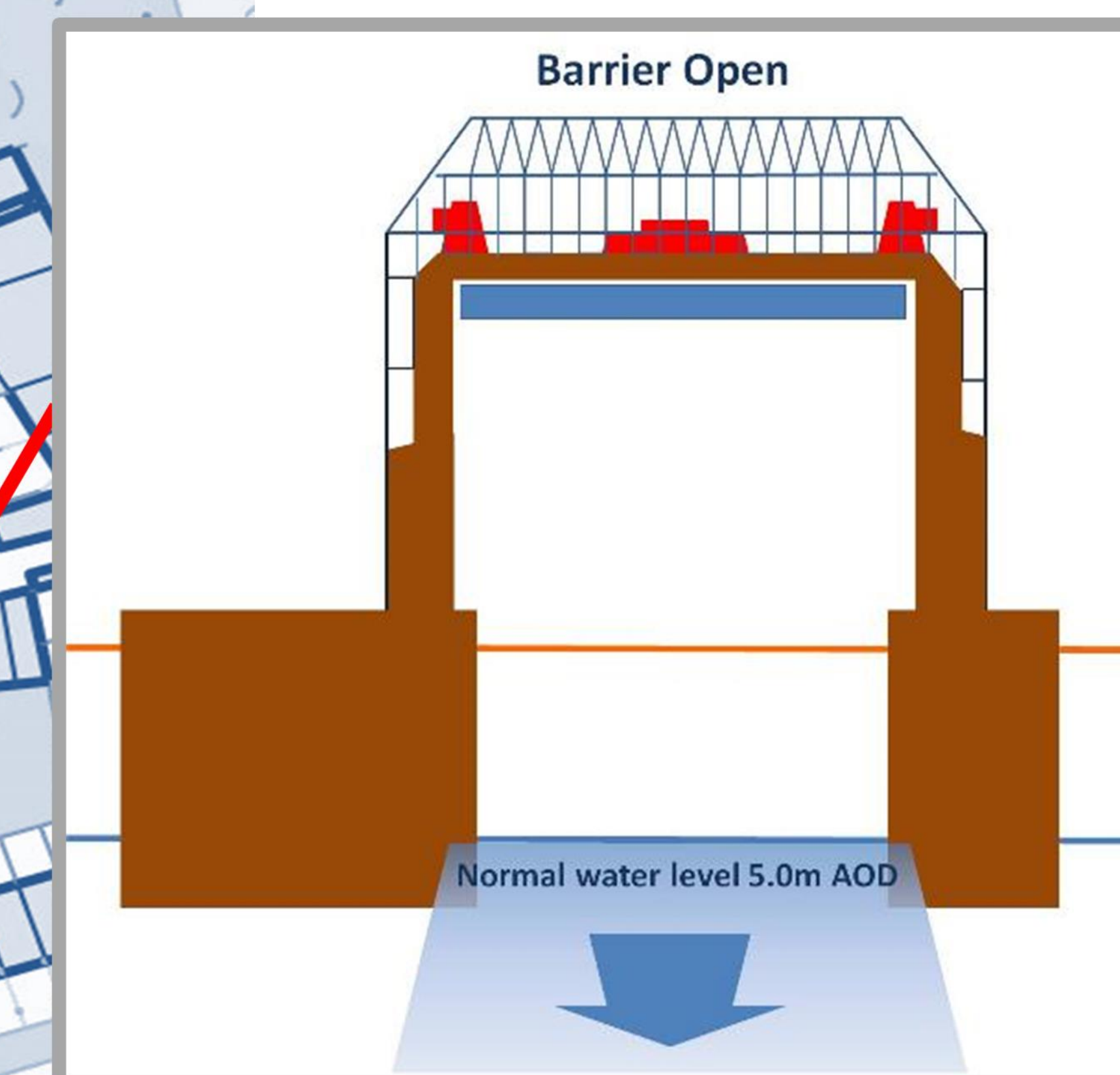
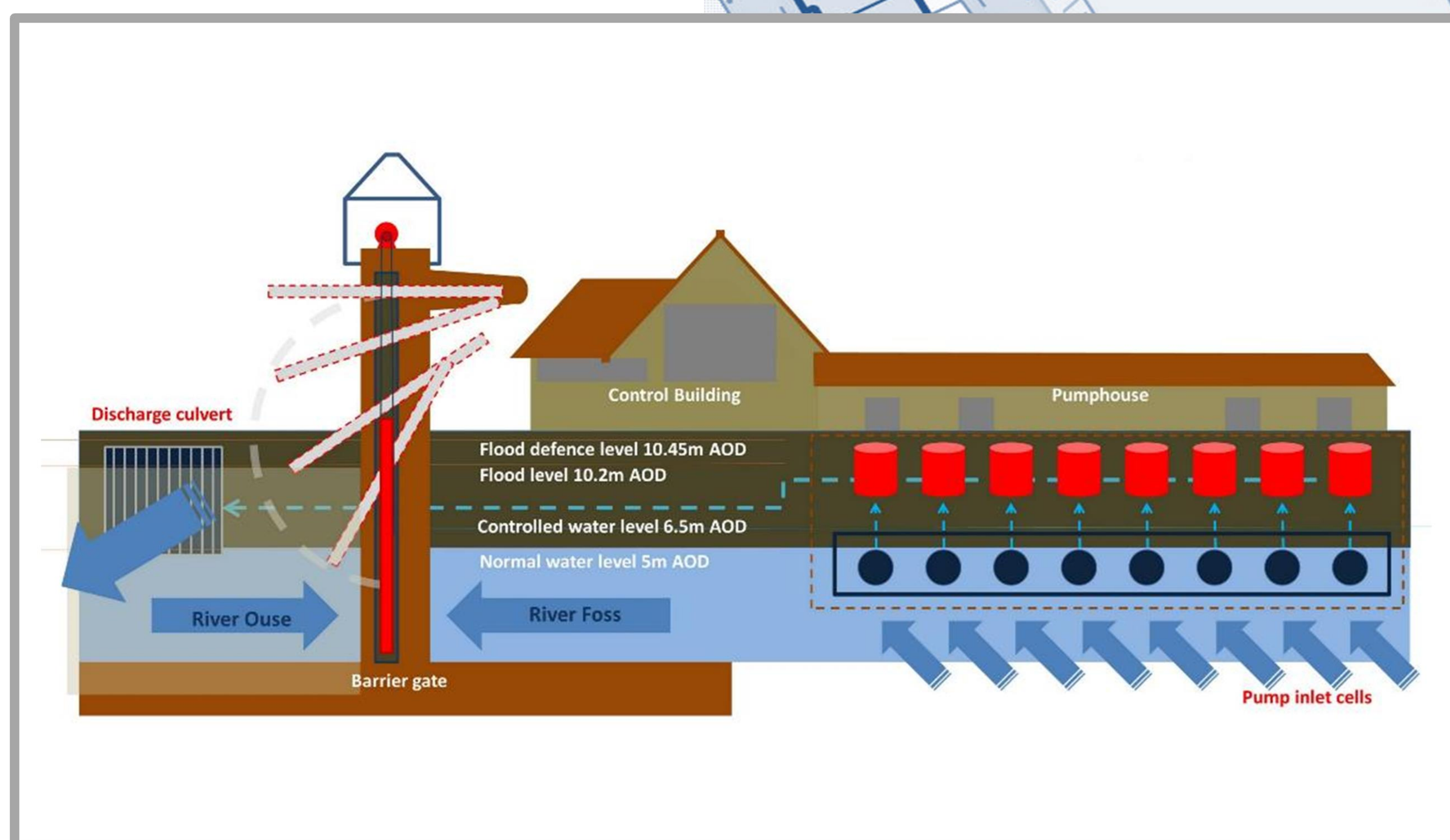
Control Building and Pump house:

Local river levels are monitored near the barrier and pumping station.

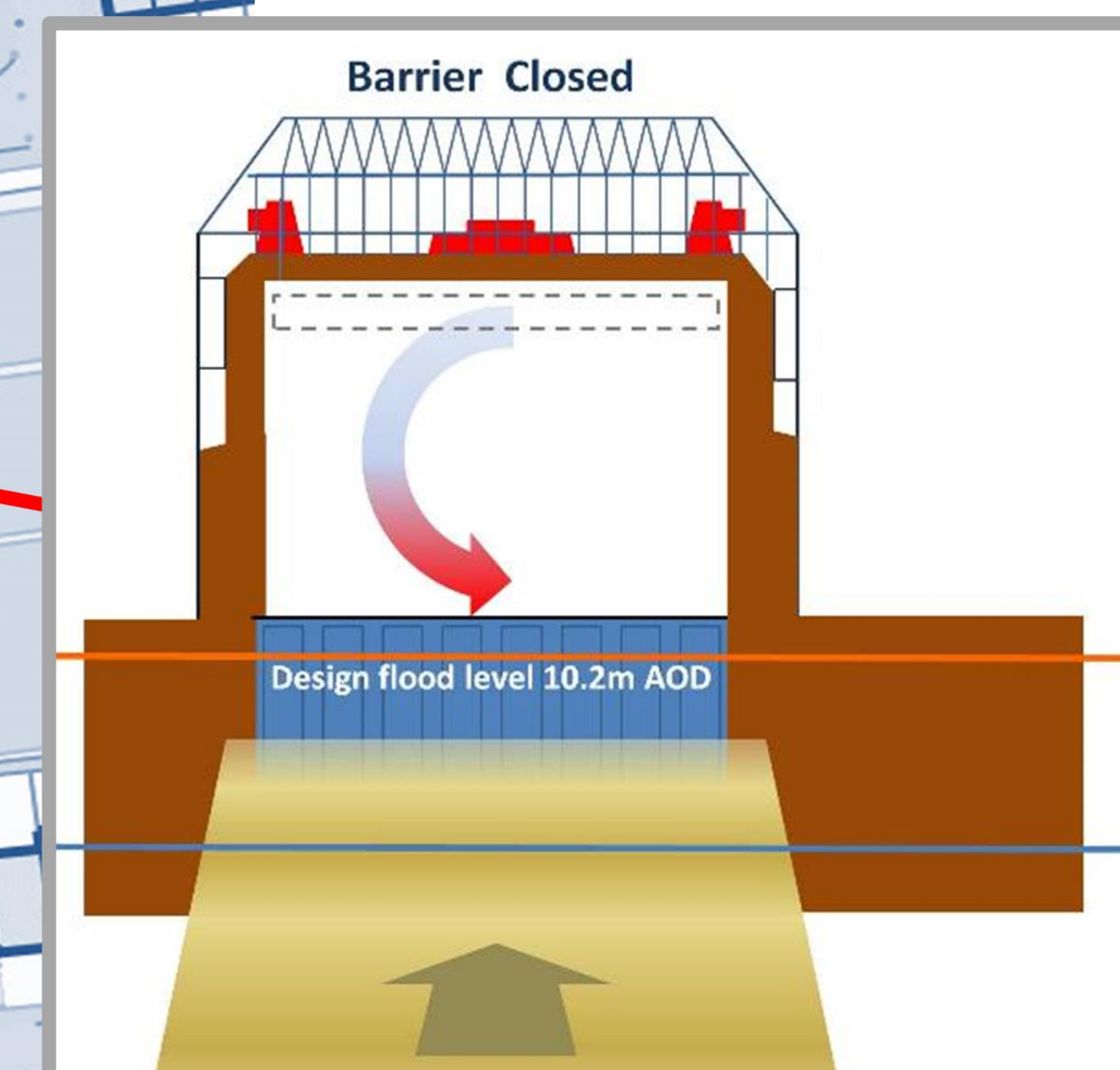
When the water level on the river Ouse reaches the set level of 7.8m AOD a warning sound alerts the operator to initiate the barrier closing sequence.

Foss Barrier

The barrier is a steel turn-over and lifting gate. Gate Span: 8.3m Gate height: 8.25m Gate weight: 16.5 tonnes



Above: Foss Barrier in open position with gate lifted, allows the water from the Foss to flow normally into the River Ouse



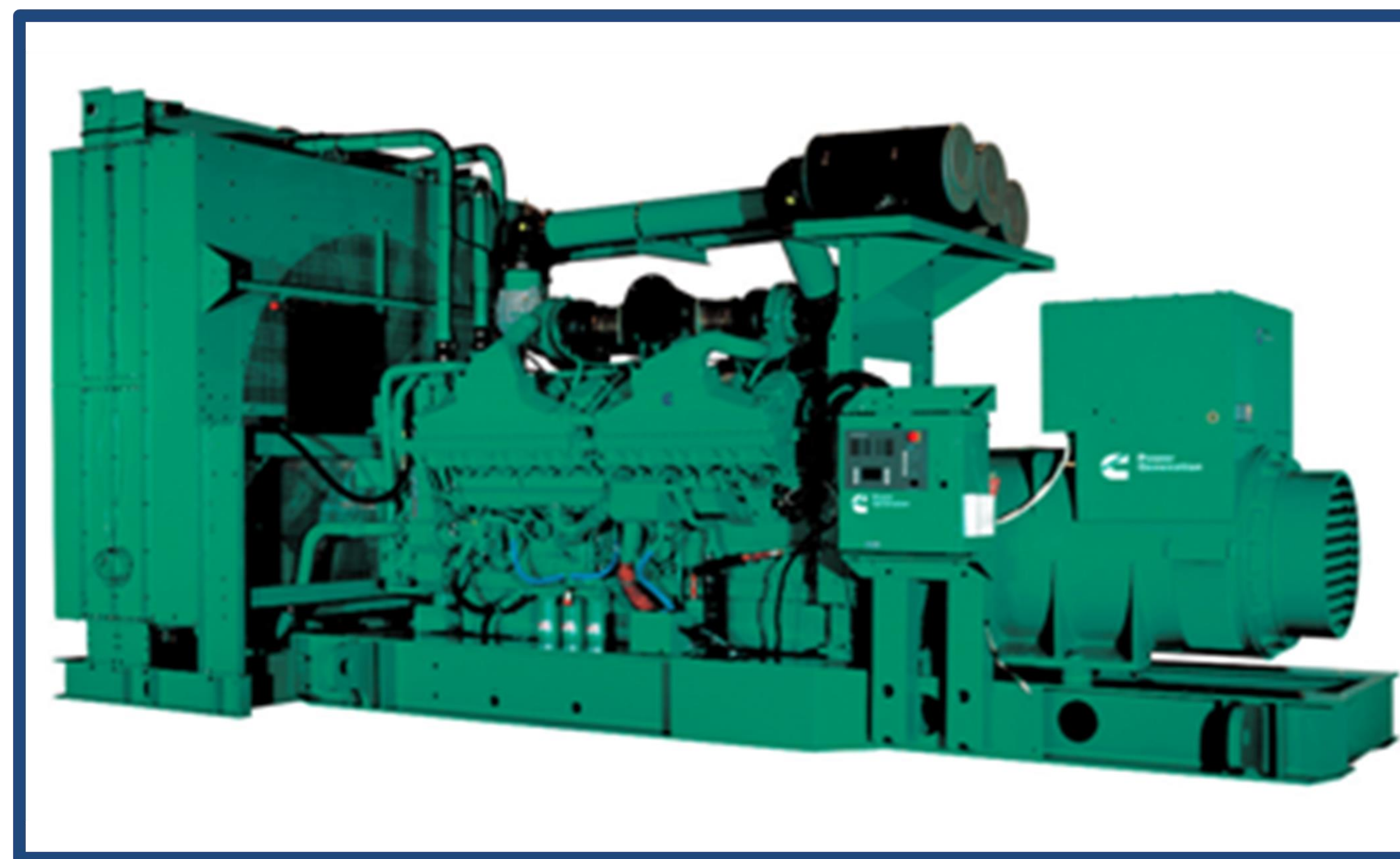
The Foss Barrier in the closed position with gate lowered into position to stop flood water from the Ouse pushing up stream into the Foss River. When the gate is closed the water in the Foss then needs to be pumped around the barrier to keep it flowing.

Improvements : Foss Barrier, York

	Equipment Location	Equipment Performance	Pump Capacity	Standby Power Generation	Power Supply
Existing	Ground Floor	Original, almost 30 years old	30 m ³ /s would empty Yearsley Pool in 35 seconds	Power delivers 15 m ³ /s	1 live - Foss Islands 1 backup - Skeldergate
Interim	Elevated approximately 1 metre above Boxing Day's water level	Existing & Newer	40 m ³ /s would empty Yearsley Pool in 27 seconds	Power delivers 30 m ³ /s	2 live - Foss Islands & Skeldergate
Permanent	Elevated approximately 1 metre above Boxing Day's water level	New	40 – 50 m ³ /s would empty Yearsley Pool in 27 to 21 seconds	Power delivers 37 m ³ /s	2 live – Melrosegate & Foss Islands 1 backup – Skeldergate



Power supplies – We will have two main power supplies and one backup.



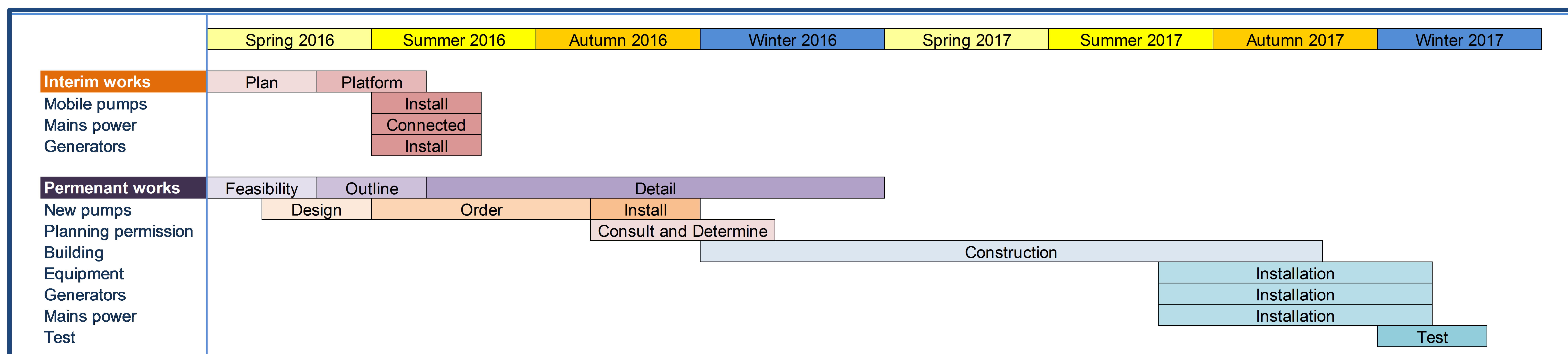
Three new generators provide backup in case of mains power failure.



Yearsley Pool holds 1,000,000 litres of water. The new pump capacity could empty the pool in 21 seconds.

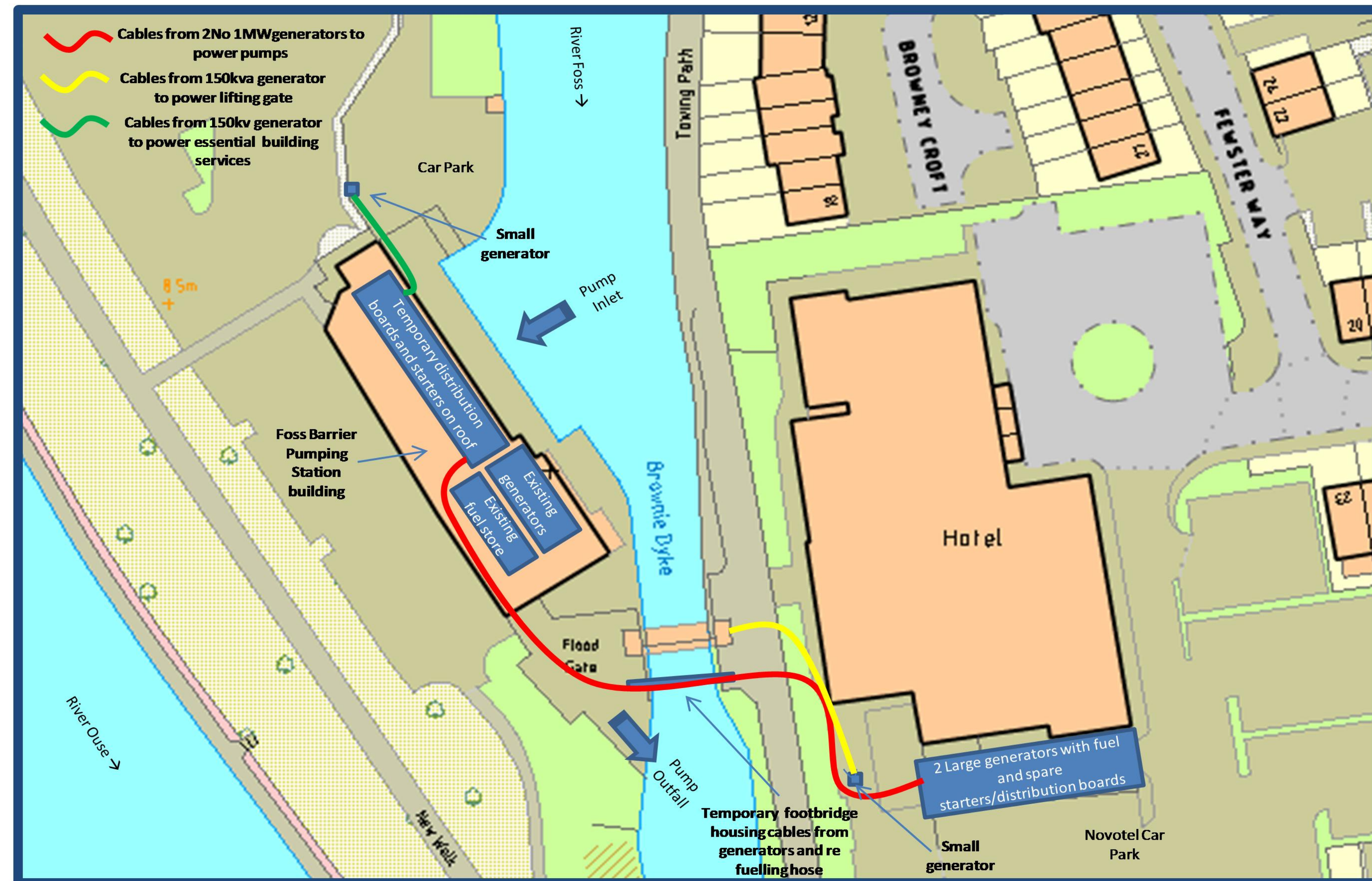


Implementing Improvements : Foss Barrier, York

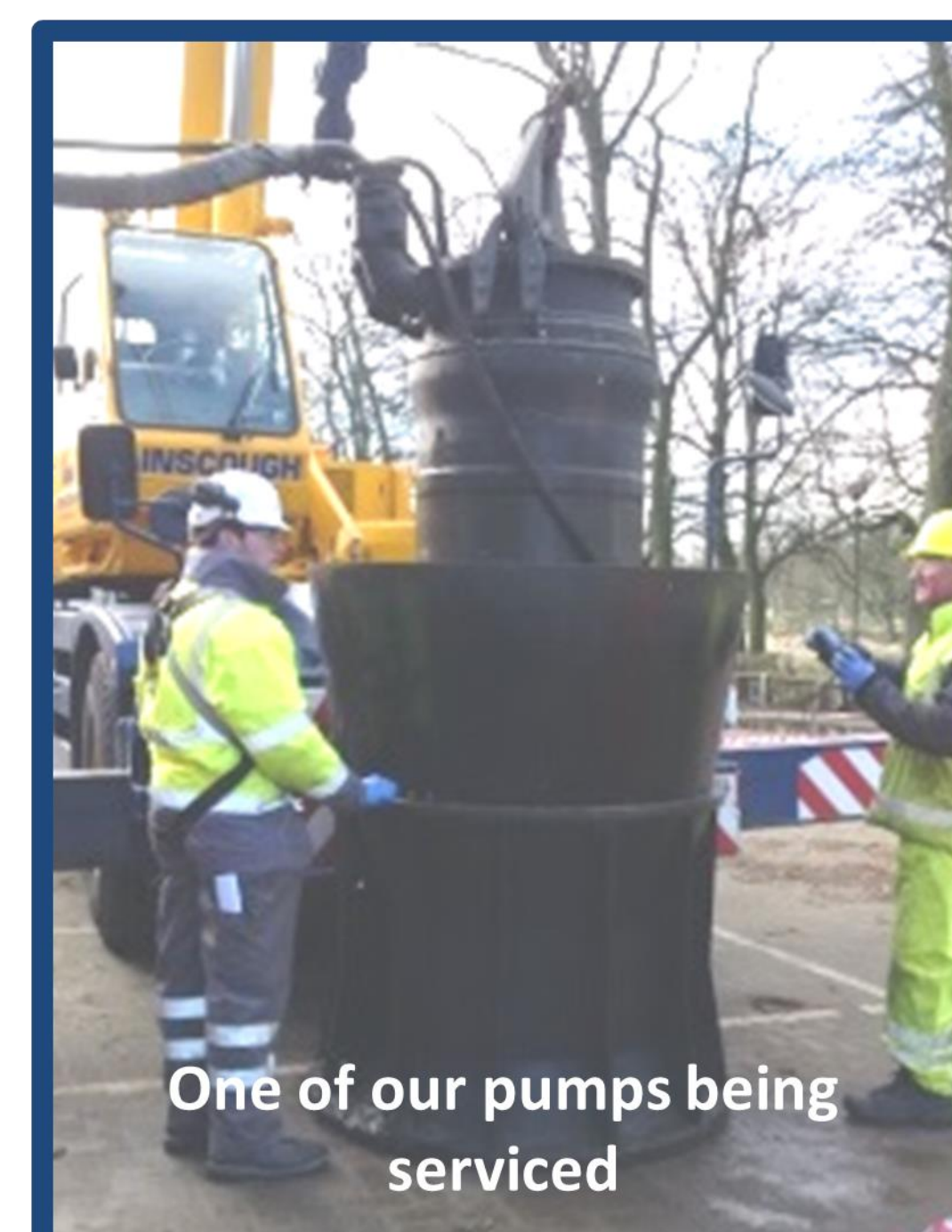


Implementing Improvements : Foss Barrier, York

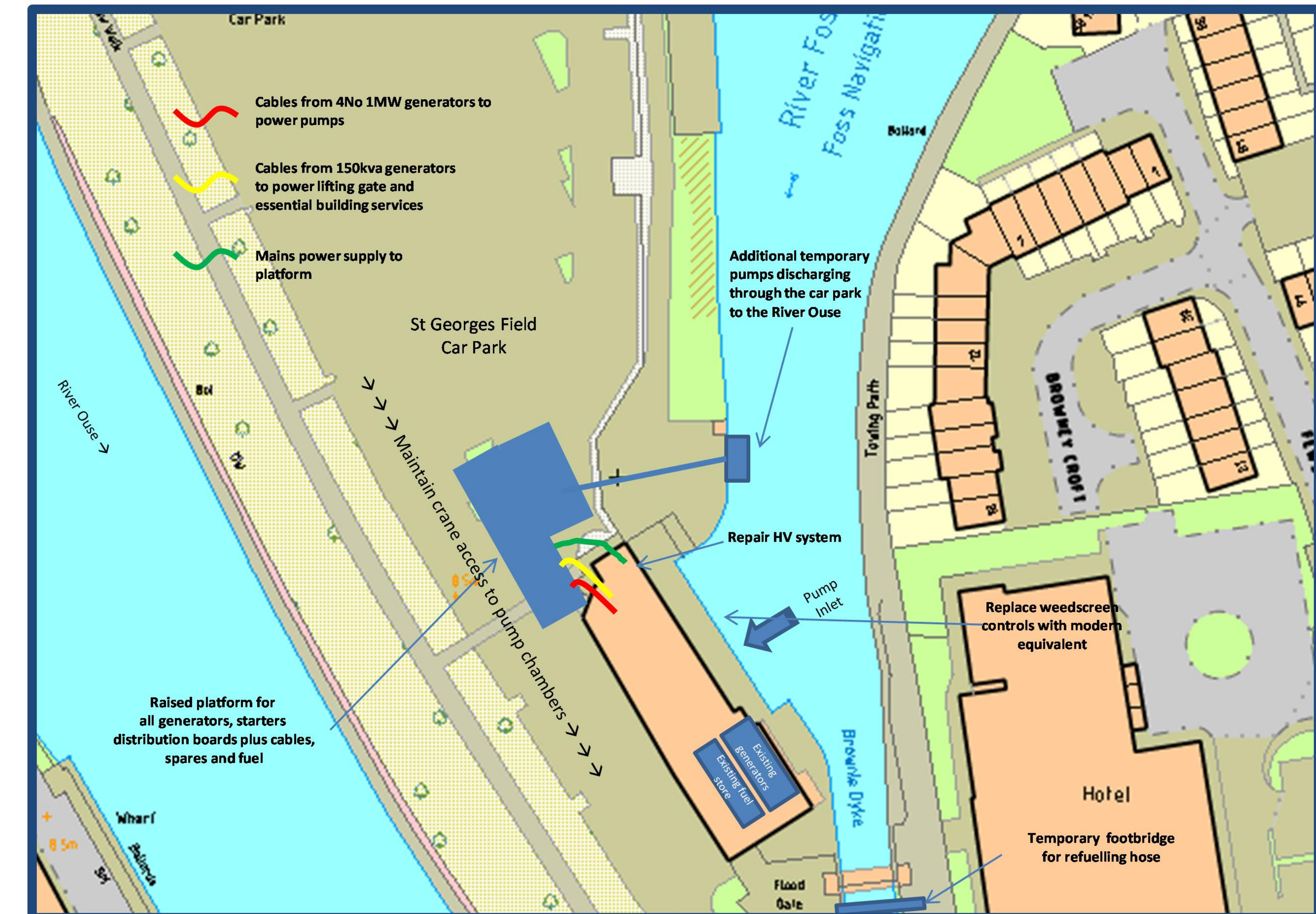
Temporary Works – current arrangement



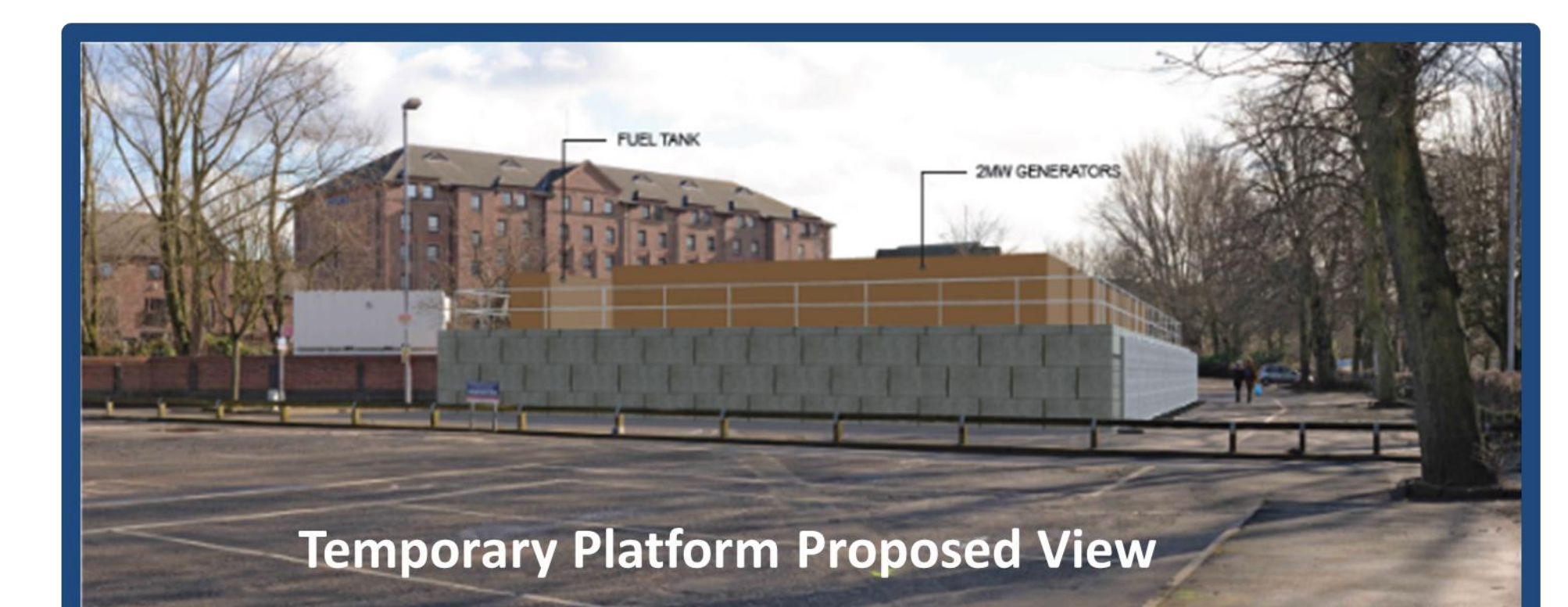
- We have all 8 pumps available providing 30 m³/s pumping capacity.
- Our barrier gate and essential building services (including Castle Mills Sluice and weed grab) are operational.
- We have pump equipment (starters and distribution boards) located on the roof of pumping station and at Novotel.
- We are using existing generators and temporary generators situated at Novotel.
- We have routed cables to provide power to pumps across a temporary bridge.
- Our pump control equipment is located above flood water level.



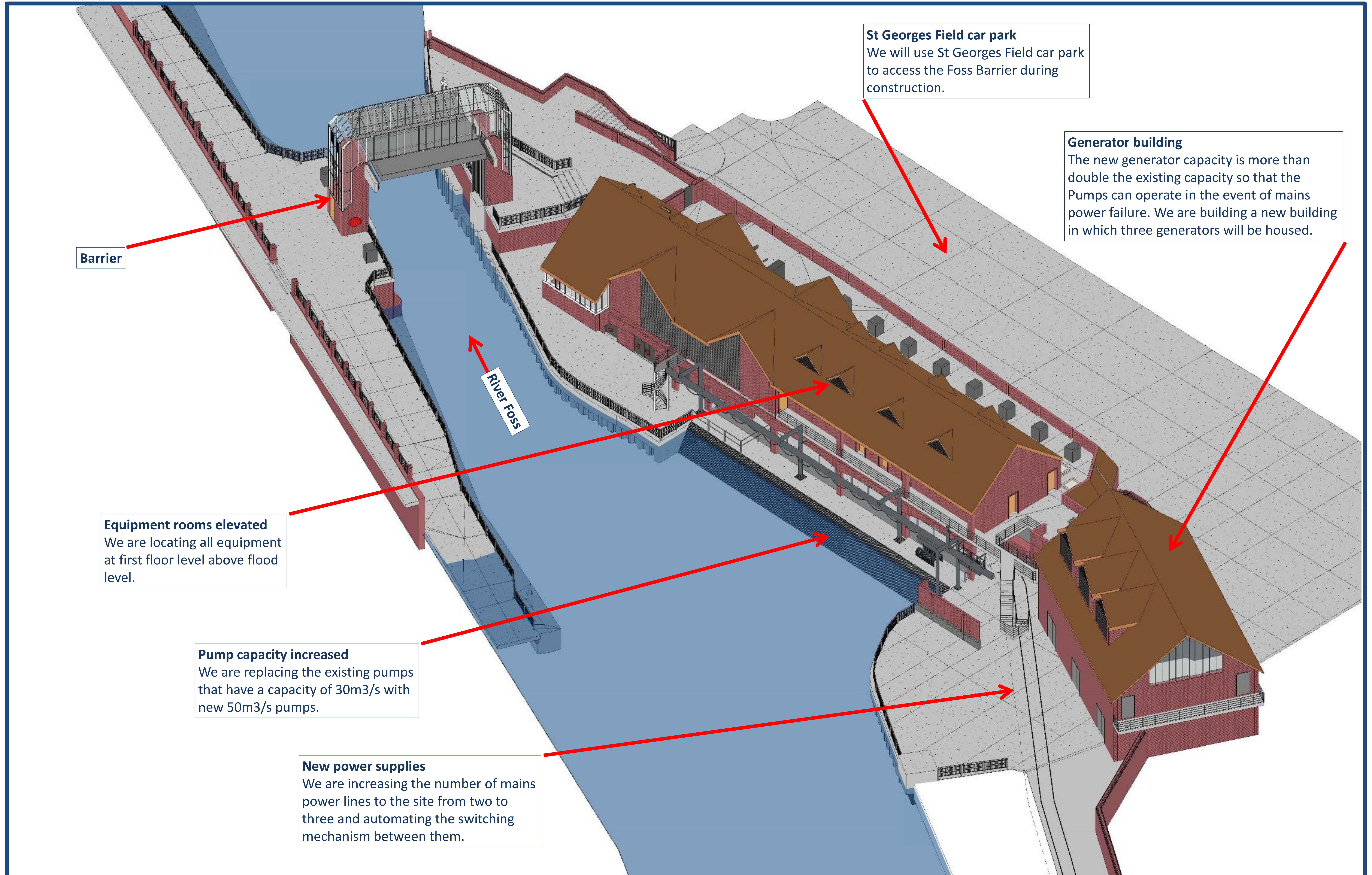
Interim Works - How we will keep it working



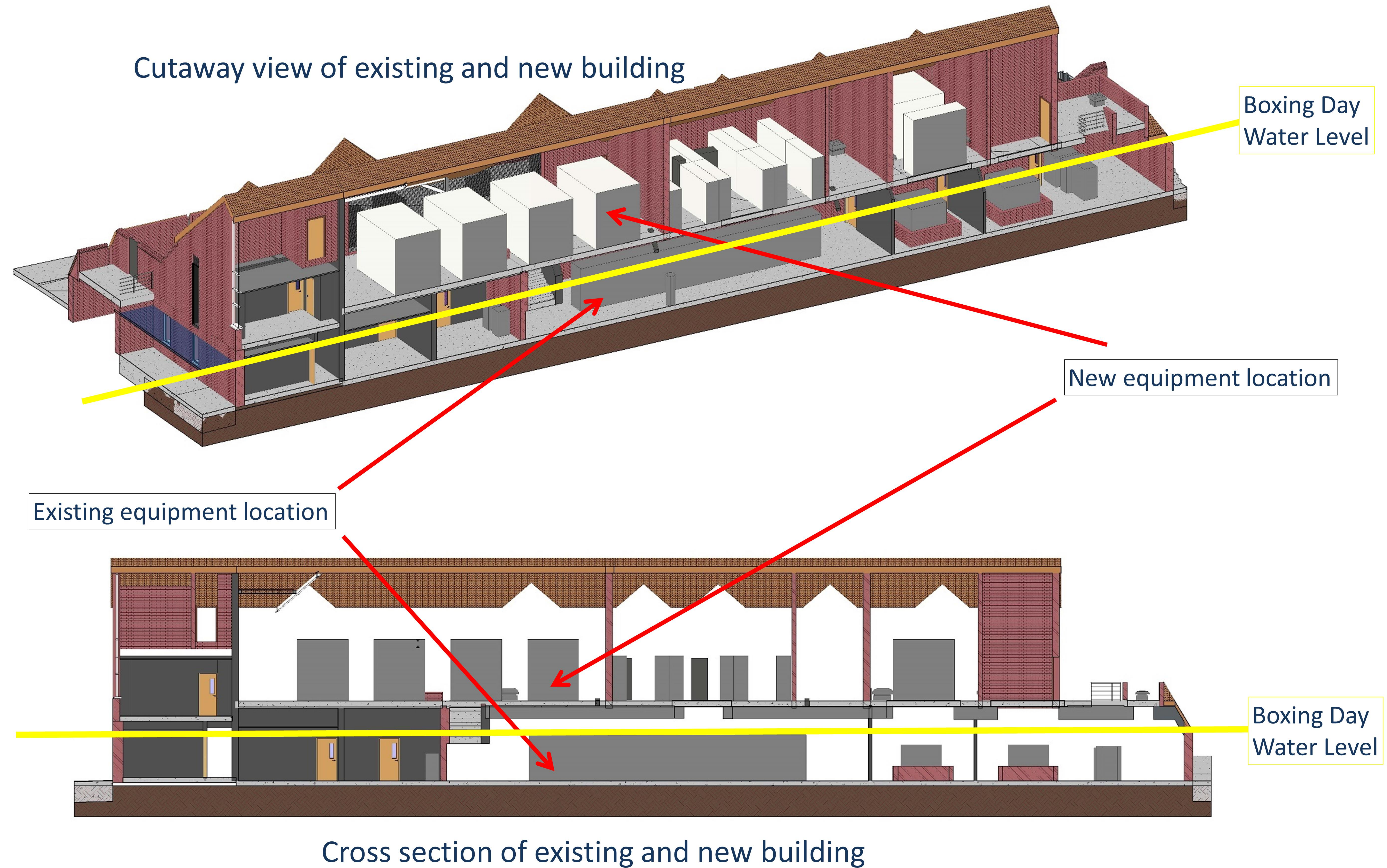
- We are building a temporary platform in St Georges Field car park to hold all electrical control equipment and generators above flood level while improvements are undertaken.
- We will re-instate the mains power supply.
- We will keep 8 pumps available powered by mains power providing 30 m³/s pumping capacity.
- We will have generator back up to power all 8 pumps.
- We are installing additional temporary pumps providing 3.5 m³/s capacity to support the existing pumps.
- We will replace existing pumps with larger pumps in late summer and early autumn to give greater pumping capacity in region of 50 m³/s.
- We will reduce the risk of water entering the ground floor where interim power supply and transformers are located.



Concept View of Improvements : Foss Barrier, York



Concept View of Improvements : Foss Barrier, York



The upgrade works will increase the capacity of the pumping station (from 30 m³/s to around 50 m³/s).

We will complete the works by November 2017 at a total estimated cost of around £17 million using £10 million direct funding and £7 million from recovery funding.

An investigation into the Foss Barrier

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Foss Barrier Investigation Report

The Environment Agency commissioned an independent investigation by CH2M to look at how water entered the Foss Barrier building on Boxing Day 2015. This investigation report was published on Thursday 12th May 2016.

For the full report, please click the below link:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/522633/Foss_Barrier_5_May_2016_FINAL.pdf

Investigation into the Foss Barrier

Keeping you informed

12 May 2016

Overview of the flooding of the River Foss, December 2015

- On Boxing Day 2015 more than 600 homes and businesses were affected when exceptionally high rainfall and river levels led to extensive flooding in the city of York.
- The flow coming down the River Foss on Boxing Day was far greater than anything recorded over the previous 30 years with the measured flow almost double that seen during the autumn 2000 flood event.

Foss Barrier – investigation report

After the floods of 26 December 2015, when water entered the building at the Foss Barrier, we commissioned an independent report to investigate why this had occurred. This report has now been concluded and published today and we wanted to let you know of its findings.

Background

As you are aware, on 26 December 2015 over 600 properties along the River Foss in York flooded. We operate the Foss Barrier and pumping station which is designed to prevent flooding by stopping the River Ouse (when in flood) backing up the River Foss. When the barrier gate is closed the River Foss is pumped around the gate with eight high capacity pumps. Unfortunately, on 26 December 2015, the pumping station was unable to cope with the extremely high flows coming down the River Foss and we turned off the eight pumps and lifted the barrier between the Rivers Foss and Ouse. This was to prevent even more serious flooding as, had the gate remained in the lowered position, water would have built up behind the gate causing the water levels in the Foss to be higher and to therefore flood further.

Water was leaking into the Foss Barrier control building putting the power supply to the building, and the ability to raise the barrier, at risk.

On 1 February 2016 we instructed consultants, CH2M, to carry out an investigation to answer the following questions:

- Determine the mechanism by which water entered the Foss Barrier Pumping Station on 26 December 2015 and;
- Identify the remedial steps that would need to be taken to minimise the risk of water entering the pumping station in the future.

Summary findings

Leakage

The report identified that the building's service tunnel and drainage network as the routes for leakage that caused flooding of the ground floor of the facility.

The building and barrier structures are built on piled foundations but the area between the two structures, where part of the service tunnel runs, is not. This caused a construction joint to open up over time, providing a route for water to leak into the service tunnel and ground floor of the building. The investigation also found that further leakage came through an external access cover, which had been removed to help pump the leakage from the building.

What happened on 26 December 2015?

On 26 December water was entering the service tunnel through the damaged seal on the construction joint. Pumping of the service tunnel and pumping from the interceptor chamber was underway.

The level of the River Foss continued to rise, even though all eight of the high capacity pumps were running. As the River Foss levels rose higher, water entered the open access chamber thereby increasing the flow in the drainage system. As a result, water filled the service tunnel until it emerged from the floor access points inside the pumping station building. This increased throughout the afternoon of the 26 December eventually flooding the ground floor of the building.

River levels

The report also made an assessment of the effect of raising the gate on river levels. The report shows that had the barrier not been lifted then levels in the Foss would have been higher than if the barrier had remained in the lowered position. The report also shows that the peak on the River Foss would have occurred some 18 hours earlier.

The report's recommendations

Service tunnel

Access openings between the building and the service tunnel should be sealed so that when water enters the service tunnel it cannot rise and flood the building.

The sealed openings will be designed to withstand the hydraulic pressures exerted on them from beneath during flood events to stop the ingress of water.

Drainage

The drainage could be configured in a way which eliminates the need to pass through the perimeter of the building below flood level ie by having a small pumping system to pump it up and over the defence height. All existing drainage routes which pass through the wall of the building would be sealed.

Water sensitive equipment

The watertight envelope of the building is reliant on door and window seals. If it is not possible to eliminate or reduce these residual risks to an acceptable level, the alternative is to move the water sensitive equipment above the flood risk level.

The current situation

The Foss Barrier is fully operational and has been used successfully since the December floods.

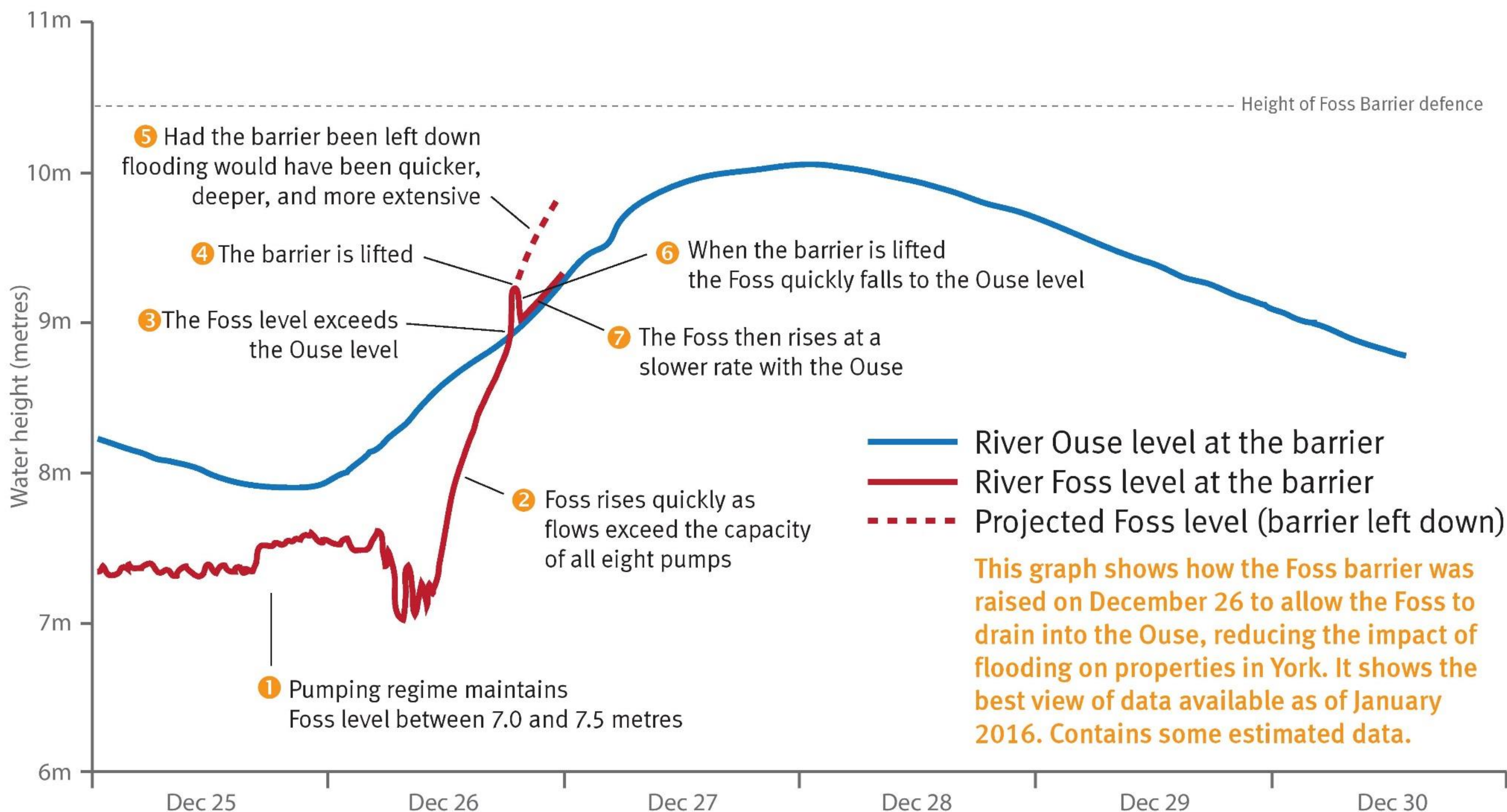
We will be including all the report's recommendations as part of the ongoing works to upgrade the barrier.

In addition, the upgrade works will increase the capacity of the pumping station (from 30cumecs to around 50cumecs).

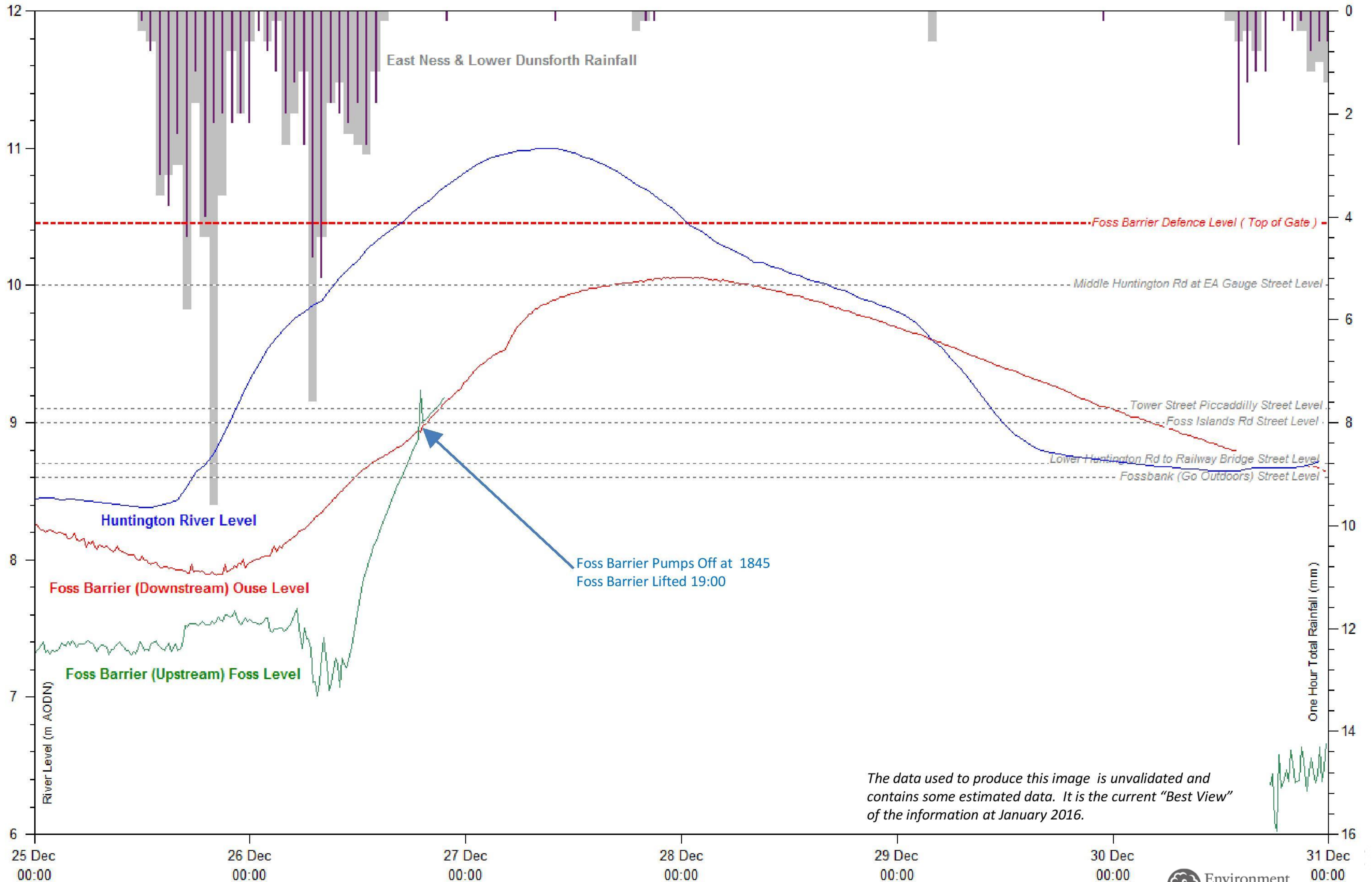
This work will be completed by November 2017 at a total estimated cost of around £17 million using £10 million direct funding and £7 million from recovery funding

River levels at the Foss Barrier

How the barrier was operated during the floods of Christmas 2015



Environment Agency Hydrograph of River Foss Rainfall and River Level 25 to 31 Dec 2015



Key

The continuous red line (Foss Barrier Downstream Ouse level) is the measurement of the river level at the Foss Barrier on the River Ouse side. Up until 19:00 GMT, the time when the green line stops, this measurement is taken from the sensor at the Foss Barrier. After this, the red line is derived from the Ouse at York Viking; which is about 400-500 yards upstream on the Ouse.

The green line (Foss Barrier Upstream Foss level) is the measurement of the river level at the Foss barrier on the River Foss side – it is a measure of the level in the Foss Basin.

The blue line (Huntington River Foss level) is the measurement of the river level of the River Foss at Huntington, 2km further upstream of the Barrier. This is the only site that records the level of the River Foss independently of the barrier. It shows what is happening to the river level in response to rainfall rather than in response to the barrier.

The red dashed line (Foss Barrier defence level) shows the top level of the barrier gate when it is the closed (in the down position). Should the Foss level exceed this height it would overtop the barrier gate and flow into the River Ouse.

The purple and grey bars at the top axis show the total rainfall per hour in mm at two raingauges. This is measure of the rain north of York around Easingwold and surrounding area and shows very heavy rainfall.

The horizontal grey dotted lines show the indicative level of the named streets (the road level in these streets does vary along their length). These streets flood from the River Foss when the level exceeds the height of the grey dotted line. For the purposes of this graph the key relationship is between the level in the Foss upstream of the barrier (the green line) and these street levels (dotted grey lines).

What do the hydrographs tell us about flooding on the River Foss on 26 December 2015?

25 December

The blue line shows the level of the River Foss upstream of the barrier at Huntingdon. The line rising shows that there is an increasing flow of water. Levels in the River Foss are rising rapidly in response to the overnight and morning rainfall (where rainfall totals per hour in mm at the two gauges are shown by the grey and purple bars at the top axis), through from the afternoon of 25 December. The increase eases off half way up the blue line where there is a kink, as the river is responding to the first period rainfall having stopped.

On 25 December through the early morning of 26 December, the inflow to the River Foss behind the barrier is matched by the ability of the pumps to discharge it into the River Ouse. The Foss river level at the barrier (shown in the green line) is holding more or less constant.

26 December morning

The very heavy rainfall in the upper part of the catchment is easing. Levels in the River Ouse (red line) are rising. From mid-morning on 26 December the blue line becomes steeper again showing that the River Foss upstream is now rising more rapidly in response to the early morning rainfall.

However, the Green line shows how levels behind the barrier are rising as the inflow from the Foss upstream (the blue line) is exceeding the capacity of the pumps to hold the basin (the green line) at a constant level.

The level on the River Foss behind the barrier (the green line) is still lower than the River Ouse level (the red line) at the other side of the barrier. This shows that the barrier is defending the Foss from inflow from the Ouse.

What do the hydrographs tell us about flooding on the River Foss on 26 December 2015?

26 December afternoon

The rainfall in the upper part of the catchment has stopped. The River Foss upstream (blue line) is continuing to rise in response to the morning rainfall. Sections of Huntington Road are under water because of the volume of water coming down the Foss.

The green line shows a steep increase in the River Foss level near the barrier, from around midday on 26 December. The Foss barrier is down and the pumps are on. The steep increase shows that although all eight pumps were operating, they were not keeping up with the inflow from the Foss and the river level behind the barrier was rising quickly. Levels in front of and behind the Foss Barrier are very close.

The level of the Foss River behind the barrier (green line) has now risen far enough that it has exceeded the road levels (dotted grey line) at both Foss Bank and Lower Huntington Road. At 16:30 there are reports of houses flooding in Huntington Road area as a result of these levels in the Foss.

The red line shows the level of the River Ouse rising through 26 December, whilst the Foss Barrier is down and the pumps are on. But it is rising less quickly than the River Foss at Huntingdon and significantly less quickly than the Foss at the barrier.

26 December evening around 7pm

The Foss Barrier pumps were turned off at 18:45 on 26 December and we then started to open the barrier. The barrier takes 10 to 15 minutes to open fully. At this time the Ouse level in front of the barrier was approximately 0.06m higher than the level in the Foss immediately upstream of the barrier. At around the time of these actions, there is a jump or spike in the green line. This is due to a combination of both shutting down the pumps and the time it takes to raise the barrier enough to allow the Foss to flow out into the Ouse.

After the spike, the green line then follows a curve which is less steep, meaning that the water level is rising less quickly in the Foss than it was when the barrier was down and all eight pumps were running. The green line then follows approximately the same line as the red line, meaning that the river levels at the barrier on both sides are the same. The Green line stops at this point because the sensors at the barriers were no longer working.

27 December

The River Foss (blue line) reaches peak levels in late morning on 27 December. It then declines as the levels are reducing.